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DAMAGE ASSESSMENT IN COMPOSITES BY ACOUSTIC-ULTRASONIC
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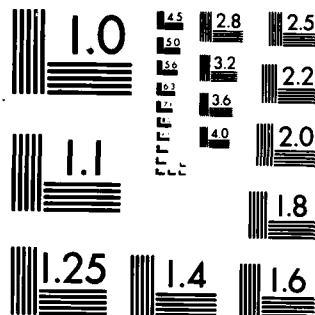
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DAMAGE ASSESSMENT IN COMPOSITES
BY ACOUSTO-ULTRASONIC TECHNIQUE

Final Report
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SUMMARY OF WORK ACCOMPLISHED

The damage development in cross-ply S-2 glass/epoxy laminates were assessed using acousto-ultrasonic (AU) and acoustic emission (AE) techniques. Acoustic emission and acousto-ultrasonic measurements gave early warnings of damage initiation before transverse cracks became visible. AU parameters such as peak amplitude, energy and stress wave factor were equally sensitive to damage initiation, but peak amplitude and energy were more sensitive to damage accumulation. Variations of peak amplitude, event duration, ringdown counts, and rise time in AU tests were analyzed to show that internal damage not only increased the apparent attenuation but also affected the wave envelope. The same effect was also present in AE tests. Acousto-ultrasonic tests of an undamaged cross-ply laminate showed that the apparent attenuation coefficients were almost independent of the wave propagation direction. The strongest wave was found along the fibers in the ply in contact with the transducers and the weakest wave traveled at an angle of 45 degrees to the fibers.

Preliminary investigations on the use of ultrasound to monitor the cure of epoxy resins have been reported in the literature. It has been observed that the speed of the ultrasonic wave increases as the resin cures while the attenuation first increases and then decreases. These changes have been qualitatively explained in terms of the changes in viscosity. In order to use ultrasonic technique to characterize property changes during cure, however, quantitative relationships between changes in the wave speed and attenuation on the one hand and changes in the elastic modulus and viscosity on the other must be established.

In order to study the feasibility of ultrasonic cure characterization,

ultrasonic data available in the literature were converted to complex moduli within the framework of the theory of wave propagation in linear viscoelastic materials. Simple spring-dashpot combinations were then used to develop a constitutive model, and the pertinent elastic moduli and viscosities were obtained from the complex moduli. The elastic moduli inferred from the complex moduli were found to agree well with the values measured by mechanical testing.

LIST OF TECHNICAL REPORTS

1. L. Lorenzo and H. T. Hahn, "Damage Assessment by Acousto-Ultrasonic Technique in Composites," Washington University, April 1986.
2. E. J. Tuegel and H. T. Hahn, "Ultrasonic Cure Characterization of Epoxy Resins: Constitutive Modeling," Washington University, Oct. 1986.

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